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MANUFACTURING OF LOWER-LIMB CUSTOM FIT PROSTETHICS SOCKET USING REVERSE ENGINEERING

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ABSTRACT

The objective of this project is the construction of an orthopaedic prosthesis for a person who has been lower limb amputated, above the knee, taking attention to the specifications of the amputation stump. Through this method the actual process of prosthesis design in rehabilitation technology is improved by applying reverse engineering and additive manufacturing technologies. The outcome of this work is a personalized prosthesis building procedure that should allow a stump-socket best fit and avoid the numerous iterations done until a proper fit is obtained with traditional methods.

INTRODUCTION

An amputation always causes consternation. It can be seen as the last recursive solution for a major health problem. This body mutilation will cause changes in amputee's life activity, their independence and self-esteem. Most of times, in lower limb amputee's, prosthetics adaptation can be a major problem in the rehabilitation field. It is not only need a supplementary effort for human body readapt to a new condition in terms of balance and movement as it is to have stump perfect fits. It is not easy to have a perfect fit between stump and prosthetics socket. To minimize this situation some biomedical engineering tools can provide mechanical conditions to solve these health problems and improve these group of people lifestyles (Eder et al., 2010).

For several years, persons who have been amputated lower limb, above the knee, had access to low-fit prosthesis once their characteristics did not depended of user's specificities. They caused them fairly discomfort, serious lesions and were extremely limited. A revolution in this type of prosthetic design began at the end of World War II with the development of new materials and a dramatic improvement in the understanding of biomechanics (Sewell et al., 2000).

The current prosthetic socket construction and fabrication process does not take patient specific parameters into account. It is based onto subjective estimations, competence and capabilities of the orthopaedic technician and therefore causes a high rate of inappropriate prosthetic supplies (Eder et al., 2010). Nowadays the people required better quality, functionality and safety in their treatment, without compromising the biocompatibility and the best way to successfully achieve their needs. Using the current techniques of production and manufacture of orthopaedic prosthetic, economic costs and time take a high value, so the new technology of additive manufacturing is one better alternative for obtaining these products (AIMME, 2010).

Through reverse engineering techniques such 3D scanning has been possible to capture stump's size and shape and have a digital 3D model to work with in order to manufacture prosthetics socket. Additive manufacturing provides an economic and fast way to directly manufacture sockets and socket moulds depending on the material to be used in prosthetic socket manufacture.

Although, additive manufacturing technology has been successfully applied in several areas as biomodeling technique (Queijo et al., 2011), in the case of orthopaedic prostheses we have to evaluate the biocompatibility properties of the material used for manufacturing. Old materials like leather, metal and wood have been replaced by thermoplastics, thermosetting resins, composite materials and more flexible materials of various kinds. All these materials are classified as biomaterials, compatible with this technology, allowing custom development orthopaedic prostheses in order to satisfy the quality requirements, functionality, safety and biocompatibility to the concerned person (Eder et al., 2010) (Sewell et al., 2000).

RESULTS AND CONCLUSIONS

With this work we can take as conclusion that reverse engineering used in conjunction with additive fabrication composes a viable alternative to the traditional methods of prosthetics manufacturing. These two constitutes a suitable technology to improve prosthetics manufacturing procedures systematization based in patient's personal characteristics.

For one side, reverse engineering through shape acquisition systems allow to acquire stump's shape and size while additive manufacturing allow socket fabrication with straight tolerances.

With technology innovation used we can obtain a virtual three-dimensional model of the person's stump and get all the exact dimensions for the same. These models allow us to create a virtual prosthesis socket where the stump fits, with no hollow spaces or places which cause excessive pressure on the soft tissues. Using the help of physical and mechanical calculations we can optimize the characteristics of the prosthesis for its results, when used, be the best. Concerning manufacturing, the prosthesis had to be built with a material chosen very carefully, in view of its functionality and its need of biocompatibility with soft tissues of the stump. The final prosthesis has all the features that satisfy the requirements of quality, functionality, safety and biocompatibility.

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